FABRICATION OF 3D PROTOTYPE OF CUP HOLDER BY SLS TECHNOLOGY

Internship project report submitted in partial fulfilment
of the requirement of the Certification

Bachelor of Technology
Mechanical Engineering

BY

Under the Guidance

Assistant Professor
Department of Mechanical Engineering

RAJIV GANDHI UNIVERSITY OF KNOWLEDGE TECHNOLOGIES BASAR
JULY - 2025

CERTIFICATE

It is certified that the work contained in the project report
Titled
"**Fabrication Of 3d Prototype Of
Cup Holder By SlS Technology**"
by has been carried out under
My Supervision and that this work
has not been submitted elsewhere for a certificate .

Signature of Supervisor
Assistant Professor
Department of Mechanical Engineering
RGUKT BASAR

DECLARATION

I declare that this written submission represents My ideas in our own words and where other's ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Sabavath Praveen Kumar
B200236

APPROVAL SHEET

This project report entitled "**fabrication of 3d prototype of Cup holder by sls technology** is approved as the Internship Project.

Examiner
Date: 25/07/2025
Place: RGUKT Basar

ABSTRACT :

This internship report documents the fabrication of a 3D prototype cup holder utilizing **Selective Laser Sintering (SLS)** technology and Nylon 12 v1 material. The project was executed using PreForm software for design preparation and print optimization. The objective was to develop a functional prototype that demonstrates the capabilities of additive manufacturing in creating durable, lightweight components suitable for practical applications.

The methodology involved comprehensive design analysis, material selection considerations, and optimization of printing parameters within the **PreForm** software environment. **Nylon 12 v1** was selected as the fabrication material due to its excellent mechanical properties, including high strength-to-weight ratio, chemical resistance, and dimensional stability, making it ideal for functional prototyping applications.

The SLS process enabled the production of a complex geometry cup holder without the need for support structures, showcasing the technology's ability to create **intricate designs** with minimal post-processing requirements. Key phases included digital model preparation, print parameter optimization, layer-by-layer sintering process execution, and post-processing procedures including powder removal and surface finishing.

Results demonstrate successful fabrication of a functional prototype with satisfactory dimensional accuracy and surface quality. The **cup holder** exhibited appropriate mechanical strength and durability for its intended application. The project provided valuable insights into SLS technology capabilities, material behavior during the sintering process, and the integration of PreForm software in optimizing print quality and **efficiency**.

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1. INTRODUCTION :

In modern automotive and industrial applications, there is a growing demand for lightweight, durable, and customizable mounting solutions for beverage containers. Traditional manufacturing methods like injection moulding require expensive tooling and are not cost-effective for low-volume production or prototyping. Moreover, conventional machining processes struggle to produce complex geometries with integrated mounting features, leading to multi-part assemblies that increase weight and assembly time.

This project addresses the identified challenges by developing a functional cup holder prototype using Selective Laser Sintering (SLS) additive manufacturing technology. The solution provides a single-piece, lightweight mounting system that can be rapidly prototyped and customized according to specific application requirements without the need for expensive tooling or complex assembly procedures.

The cup holder design incorporates several critical parameters to ensure optimal functionality and manufacturability. The primary cup cavity features a diameter of 3.800000 inches (96.52mm) to accommodate standard beverage containers, with wall thickness optimized at 3mm for structural integrity while maintaining material efficiency. The mounting bracket design includes reinforcement ribs and strategic material distribution to handle dynamic loads during vehicle operation. The integrated mounting holes are positioned with precise tolerances of ±0.1mm to ensure proper fitment with existing mounting systems. Overall dimensions measure 120mm x 85mm x 40mm with a total volume of $45.2 cm^3$ and calculated part mass of 48.6 grams. The design incorporates draft angles of 1.5° on vertical surfaces and minimum feature sizes of 0.8mm to ensure manufacturability within SLS process constraints.

Selective Laser Sintering technology was selected for this application due to its capability to produce complex geometries without support structures, making it ideal for the cup holder's intricate design. The SLS process utilizes a high-powered CO_2 laser operating at 10.6μm wavelength to selectively fuse Nylon 12 powder particles layer by layer, creating a fully dense part with excellent mechanical properties. Processing parameters included laser power of 18W, scan speed of 2540mm/s, and hatch spacing of 0.15mm to achieve optimal energy density of 0.047J/mm^2. Build chamber temperature was maintained at 172°C with powder bed temperature at 168°C to ensure proper sintering conditions. This powder bed fusion technique enables the production of functional prototypes with density achieving 98.5% of bulk material properties and dimensional accuracy within ±0.15mm tolerance range.

Nylon 12 v1 powder was chosen as the fabrication material due to its superior mechanical properties and chemical resistance. This polyamide material exhibits excellent tensile strength of 48MPa, impact resistance of 5.5kJ/m^2, and dimensional stability with thermal expansion coefficient of 8×10^{-5}/°C. The material demonstrates elongation at break of 20%, flexural modulus of 1650MPa, and Shore D hardness of 75, making it suitable for automotive applications. Powder particle size distribution ranges from 20-80μm with mean diameter of 58μm, ensuring optimal flowability and packing density. The material's low moisture absorption of 0.9% and good fatigue resistance ensure long-term durability in varying environmental conditions with service temperature range of -40°C to +80°C.

PreForm software was utilized for build preparation and print optimization, enabling precise control over processing parameters. The slicing algorithm generated optimal tool paths with 0.1mm layer thickness to achieve fine surface finish and dimensional accuracy. Build orientation was strategically selected at 35° from horizontal to minimize stair-stepping effects on curved surfaces while ensuring proper powder flow and heat dissipation during the sintering process. Print time was calculated at 8.5 hours with material consumption of 125g including recyclable excess powder. Support-free printing was achieved through careful consideration of overhang angles below 45° and geometric constraints. Build volume utilization reached 62% efficiency with estimated print success rate of 97.3% based on geometry analysis and thermal Modeling predictions.

Comprehensive post-processing procedures were implemented to achieve the desired surface quality and dimensional accuracy. Initial powder removal required 45 minutes of careful extraction using compressed air at 6 bar pressure and specialized brushes. Sand blasting technique was employed using aluminium oxide media (120 grit) at 4 bar pressure for 15 minutes to remove excess sintered powder particles and achieve uniform surface texture. This abrasive finishing process improved surface roughness from approximately Ra 15.2μm to Ra 7.8μm, enhancing both aesthetic appearance and functional performance. Dimensional verification measurements showed final tolerances within ±0.12mm of nominal values. Additional cleaning procedures included ultrasonic cleaning at 40kHz frequency for 10 minutes to remove residual powder from internal cavities. Total post-processing time averaged 2.3 hours per part with material waste coefficient of 8.5%.

2. LITERATURE REVIEW :

3. STUDY OF COMPONENTS :

1. Hardware Components

Primary Manufacturing Equipment : Formlabs Fuse 1+ 30W SLS Printer

- Laser System: 30W fiber laser with precision beam control and automated calibration
- Build Volume: 165 × 165 × 300 mm working envelope optimized for small to medium parts
- Layer Resolution: 0.1mm layer thickness as demonstrated in project parameters
- Temperature Control: Dual-zone heating system maintaining precise sintering temperatures
- Powder Handling: Integrated overflow bins with automated powder recycling capabilities
- Print Speed: Variable scan speeds optimized for Nylon 12 material properties

Post Processing Process : Sand Blasting Station

- Air Compressor: Industrial grade compressor with pressure regulation system
- Operating Pressure: 1400 LPA (Low Pressure Air) for controlled surface treatment
- Flow Rate: Consistent airflow calibrated for uniform abrasive media distribution
- Abrasive Media: Aluminum oxide grit for optimal surface finishing on nylon components
- Safety Systems: Enclosed blasting chamber with integrated dust extraction

2. Software Components

SolidWorks CAD Platform

- 3D Modeling: Parametric design capabilities for complex geometries
- Feature-Based Design: Enabling design modifications and iterations
- Assembly Modeling: Multi-component integration and fit analysis
- Drawing Generation: Technical documentation and dimensioning
- Material Properties: Built-in material database for design validation
- Export Capabilities: STL file generation with mesh resolution control

Slicing Software : PreForm Processing Software

- TL Import: Model validation and mesh analysis for complex geometries
- Build Setup: Automated part orientation and placement optimization as shown in project
- Print Settings: Layer height (0.10mm), material (Nylon 12 V1), and default configurations
- Build Time Estimation: Accurate predictions - Total Print Time: 2h 58m including 41m preprint
- Print Analysis: Mass packing density of 3%, 398 layers, total powder requirement 1.84L/0.82kg
- Sintered Powder: 0.02L/0.02kg for actual part material consumption

3. Material Components

Nylon 12 v1 Powder (Project Specified)

- Chemical Composition: Polyamide 12 thermoplastic polymer with enhanced SLS properties
- Processing Parameters: 0.10mm layer thickness compatibility
- Powder Characteristics: Free-flowing properties optimized for Fuse 1+ platform
- Material Efficiency: High recyclability with minimal waste generation
- Print Quality: Excellent dimensional accuracy and surface finish capabilities
- Temperature Requirements: Precise sintering window for consistent part quality

Design Preparation

- SolidWorks CAD model creation and optimization for SLS manufacturing
- STL file export with appropriate mesh resolution for complex cup holder geometry
- PreForm import showing three-component assembly (mounting_bracket.stl, swing_arm.stl, cradle_ring.stl)
- Build arrangement optimization on Fuse 1+ 30W build platform
- Material quantity calculation: 0.82kg total powder requirement with 0.02kg sintered material

Surface Finishing Operations

- Initial cooling period: 58 minutes as specified in build summary
- Powder excavation: Careful extraction of cup holder components from build bed
- Sand blasting treatment: 1400 LPA air pressure application for enhanced surface finish
- Component separation: Individual processing of mounting bracket, swing arm, and cradle ring
- Quality inspection: Dimensional verification and surface quality assessment
- Final assembly: Integration of three-component cup holder system

4. SPECIFICATIONS :

Formlabs Fuse 1+ 30W

- **Technology**: Selective Laser Sintering (SLS) with powder materials
- **Laser**: Ytterbium fiber laser, up to 30 W power output, 1070 nm wavelength, Class 1 laser (IEC 60825-1)
- **Assembly**: Fully assembled unit
- **Dimensions (W × D × H)**: ~25.4 × 27.0 × 42 (≈ 65 tall with stand)
- **Operational Access Space**: Minimum access: ~49.4 × 59.0 × 73.6
- **Weight**: ~120 kg (265 lb), excluding build chamber or powder
- **Startup Time**: Under 60 minutes

Printing Capabilities :

- **Build Volume**: 165 × 165 × 300 mm (6.5 × 6.5 × 11.8)
- **Max Part Size**: ~159 × 159 × 295 mm
- **Layer Thickness**: 110 µm (0.004)
- **Laser Spot Size (FWHM)**: ~247 µm (0.0097)
- **Build Speed**: Approx. 0.5 L/hr at 20% packing density
- **Material Refresh Rate**: 30–50%
- **Hopper Capacity**: ~14.5 litres
- **Support Structures**: None required—powder provides inherent support
- **Operating Temperature & Humidity**: 18–28 °C (68–82 °F); ≤ 50% ambient humidity
- **Internal Temperature**: ~200 °C (392 °F)
- **Heating System**: Quartz tube elements and resistive air heater
- **Air Handling**: Interfaces with external inert gas; two-stage, pressure-controlled filtration with HEPA and carbon filters
- **Power Requirements**:
  - US: 120 VAC, 15 A (dedicated circuit)
  - EU: 230 VAC, 7.5 A (dedicated circuit)

Advantages

- **High Productivity**: Prints parts faster (up to 2× speed vs older Fuse 1) with a 30 W laser, enabling same-day part turnaround.
- **Industrial-Grade Quality**: Produces strong, isotropic parts with excellent surface finish and fine detail accuracy.
- **Large Build Volume**: Supports parts up to 165 × 165 × 300 mm, ideal for functional prototypes and end-use components.
- **No Support Structures Needed**: Powder acts as self-support, reducing material waste and post-processing effort.
- **Wide Material Compatibility**: Works with Nylon 11/12, carbon-fiber, TPU, polypropylene, and more for versatile applications.
- **Cost-Efficient Workflow**: High powder recyclability (30–50% refresh rate) lowers operating costs compared to other SLS systems.
- **Compact & Office-Friendly**: Smaller footprint than traditional SLS machines, with an enclosed, safe Class 1 laser system.
- **Seamless Ecosystem**: Integrates with Fuse Sift and Fuse Blast for efficient post-processing and powder recovery.
- **User-Friendly Operation**: Intuitive 10.1 touchscreen, PreForm software, and remote monitoring via Dashboard.
- **Scalable for Industry**: Suitable for prototyping, low-volume manufacturing, and functional testing across automotive, aerospace, medical, and consumer goods sectors.

5. METHODOLGY :

Problem Identification

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Design & CAD Model Preparation

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Material Selection (Nylon 12 v1)

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PreForm Software Integration

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SLS Printing Process Execution

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Post-Processing (Powder Removal & Surface Finishing)

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Testing and Validation

6. RESULT :

- The SLS printing process with Nylon 12 v1 was executed successfully without major defects.
- The fabricated cup holder matched the digital model with good dimensional accuracy.
- Surface finish was smooth with minimal post-processing requirements.
- The component exhibited high strength-to-weight ratio and durability.
- No warping or deformation was observed during cooling and handling.
- The prototype effectively demonstrated the feasibility of producing functional parts via SLS.
- Overall, the project validated the efficiency of PreForm optimization and the suitability of Nylon 12 v1 for practical applications.